Nowcasting Landspouts: A Case Study from June 18, 2010

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1. Introduction

Landspouts, short-lived tornadoes with winds of generally less than 60 mph (or weak EF0 strength), are a frequent occurrence in East Central Florida, especially in the wet season (late May-mid October). These weak tornadoes make up the vast majority of East Central Florida's annual tornado count (Fig. 1). Thus, understanding their development and characteristics is essential to efficient operational nowcasting and warning dissemination at the National Weather Service Weather Forecast Office in Melbourne, Florida (WFO MLB).

The precursor to being able to alert the public of such phenomena is knowing the environmental conditions that produce such events, both on the synoptic and mesoscales. Being comfortable with one's environmental assessment and analysis is key in knowing what to be on the lookout for once convection initiates. This includes analyzing both objective observations and numerical model data, while being critical of model data and sensitive to its initial conditions.

Remote sensing techniques must be employed once thunderstorms develop, mainly via the use of Doppler radar. The National Weather Service's Weather Surveillance Radar 1988 Doppler (WSR-88D) is the main tool used to analyze and interrogate these storms, although many NWS offices also have access to Terminal Doppler Weather Radars (TDWRs) at major airports. Having accurate and reliable radar data is absolutely crucial in allowing NWS meteorologists to warn their users and get people to safety, as this is the primary means of understanding the dynamics of a storm. Satellite data from geosynchronous orbiting satellites is also heavily relied upon to analyze storms in real time.

This study will examine a case from 18 June 2010, when a well-documented landspout touched down west of Vero Beach, Florida. The environment will be assessed by using observational and model data. Radar data from the KMLB WSR-88D will also be analyzed to aid forecasters in understanding favorable conditions for landspout development. In addition, some applications for operational nowcasting and recommendations for WFO MLB products, including enhanced wording, will be presented.

2. Environmental Setup

A typical Florida wet season pattern was observed on 18 June 2010. Figure 2 shows the Florida peninsula situated between two high pressure systems with a weak surface low across Southeast Georgia. Surface winds were west to northwest around 5 knots across the interior portions of the state, while the Atlantic Coast was experiencing easterly flow at the surface. The low to mid-levels show the corresponding trough axis embedded amid 2 ridge axes in weak 5 to 10 knot flow. This surface low and trailing surface trough helped initiate convection over central portions of the Florida peninsula, which will be shown in Section 3. The 1500 UTC Cape Canaveral, Florida (XMR) sounding shows deep moisture through 550 mb with a precipitable water value around 1.9 inches (Fig. 3). Low-level lapse rates were dry adiabatic through 950 mb with conditional instability through the mid-levels. This sounding also shows appreciable drying in the 500 to 425 mb layer below convective cloud tops, promoting the potential for evaporative cooling and downdrafts.

This light flow summer pattern is conducive to sea breeze formation during the late morning to early afternoon hours. The east coast sea breeze is a lifting mechanism for daily convection across East Central Florida during the wet season. Light flow throughout the depth of the troposphere is normal for the region, due to the strong persistent presence of the Bermuda ridge axis. Therefore, the mesoscale influence of the east coast sea breeze is able to dominate the synoptic scale flow on a routine basis. However, westerly synoptic flow through the low and mid-levels represents a scenario for enhanced convergence as it interacts with the westward propagating east coast sea breeze.

With weak vertical wind shear, as is regularly the case at this time of year, pulse type thunderstorms are the most common. Once the source of lift from the sea breeze is gone, storms begin their descent and weaken rapidly as the cold pool overtakes the updraft(s).

3. Radar Analysis

Beginning at 1800 UTC on 18 June 2010, a convective cell and associated southeastward propagating outflow boundary are present on radar (Fig. 4). This cell just southeast of Orlando was produced by the lift associated with the low-level trough axis. Initiation of the east coast sea breeze had begun, evidenced by the fine line moving onshore from the Atlantic Coast and isolated cells along and behind it.

The large-scale outflow boundary, from the preexisting convection southeast of Orlando, and the east coast sea breeze continued approaching one another through the afternoon. By 1856 UTC, Figure 5 shows a line of storms which developed from northwestern Okeechobee County to northwestern Indian River County as the result of low-level convergence from the two boundaries. A few cells had also developed to the south near Port St. Lucie along the southern periphery of the sea breeze.

Radar imagery from 1956 UTC shows an outflow boundary that resulted from the line of storms formed an hour ago by the initial boundary (Fig. 6). This secondary outflow boundary was producing enhanced lift and convergence to its southeast, intensifying the cluster of cells previously formed near Port St. Lucie along the southern end of the sea breeze.

The original southeastward propagating outflow boundary was located on a line from near Micco to west of Vero Beach and Interstate 95 at 2039 UTC, and it had now intersected a cluster of northward moving convection (Fig. 7). By 2056 UTC, Figure 8 shows this intersection having produced a pendant echo in the reflectivity data, which signifies the landspout. This signature disappeared as the boundary exited the vicinity of the cell. Looking at the 2056 UTC base velocity data, there does not appear to be much of any resolvable circulation (Fig. 9). However, a low-level divergence signature is present at the site where the landspout occurred.

Choy and Spratt (1993) developed a technique based on radar trends to forecast waterspouts. In addition to base data analysis, trends were examined in composite reflectivity, echo tops and vertically integrated liquid (VIL). This technique was used here due to the similarity between waterspouts and landspouts. Intensification of composite reflectivity, echo tops and VIL can be seen in comparison with base reflectivity up until formation of the landspout at 2056 UTC (Figs. 10-12). This is consistent with what was seen in relation to waterspouts in the Choy and Spratt study. The amplification in these products correlates with being in close proximity to an outflow boundary intersecting with preexisting convection. As the boundary exits the vicinity of the convection and the landspout develops, the three aforementioned products show reduction in overall strength and organization (Figs. 12-14). This has to do with the lifting and stretching of vorticity in the low-levels that results from low-level boundaries.

Lightning trends were also evaluated using the Advanced Weather Interactive Processing System (AWIPS) 15 minute lightning plot. The same idea is at work here, in that lightning activity shows a marked increase in intensity and concentration right before landspout generation (Figs. 15-17). Flash density decreases and the compact cluster of strikes elongates after the boundary passes and the landspout occurs (Figs. 17-18).

4. Applications for Operational Nowcasting

This case study demonstrates the type of environment conducive for landspouts and can be used as a reference by operational forecasters. The synoptic environment was primed for afternoon thunderstorm generation along the east coast sea breeze, and preexisting convection to the northwest produced a strong outflow boundary that persisted into the latter half of the afternoon. Multiple periods of convective initiation occurred from boundaries intersecting and associated thunderstorms intersecting those boundaries, producing many mesoscale boundaries from each period of initiation further producing more storms. Composite reflectivity, echo tops and VIL increasing concurrently in vicinity to a boundary-thunderstorm interaction is a sign that a strengthening storm may produce a brief weak landspout spinup. These parameters weakened during and after landspout development. Lightning activity also increased up until landspout formation before decreasing afterwards.

It is important to be aware of downdrafts in a boundary-rich environment and the processes that accentuate them. Pulse storms often result in precipitation loading, and dry mid-level air promotes evaporational cooling. These downdrafts can interact with boundaries to produce additional lifting and stretching of vorticity as the atmosphere further destabilizes. Keeping radar sampling limitations in mind is vital in mesoscale cases such as this. The circulation associated with a landspout (or waterspout) is on the order of one magnitude smaller than the highest resolution available from any available radar product, causing these circulations to be virtually unresolvable. This is likely the reason the circulation was not evident in the velocity data.

5. Recommendations for Forecasters and Suggestive Wording in NWS Products

To enhance operations at WFO Melbourne, recommendations were developed to aid in the forecasting and nowcasting of landspouts. This was done by evaluating the three main products the office would use in alerting the public of such a hazard: The Hazardous Weather Outlook and Graphical Hazardous Weather Outlook, issued by 6 AM every morning, should highlight the threat for landspouts when the environmental and mesoscale setups are similar to what they were in this particular case. This includes having a trough axis over Florida with a conditionally unstable air mass. Dry air below cloud tops, but sufficiently far enough above the surface for evaporative cooling to aid in increasing instability, is another important factor to consider. A product unique to the Melbourne office, the Impact Weather Update, is issued several hours in advance of impact weather. Therefore, issuing a Blog (which also gets issued as a Nowcast) to emphasize landspout potential is a good best practice for WFO MLB forecasters. It would also be proactive to include a brief statement in NWSChat.

Subsequently issuing a Tornado Warning would be the most accurate way to handle a landspout occurrence. However, this is often impossible to do by using WSR-88D data due to resolution issues. Therefore, issuing a Special Weather Statement for landspouts and funnel clouds is the best approach in this situation. This allows the public to be informed of a potential landspout, and it keeps the office's false alarm ratio from rising to extreme values. Forecasters must watch for rapid cell growth along boundaries and boundary "intersection" as opposed to boundary "collision." The near-perpendicular intersection of two boundaries can allow for very localized lift in the presence of extreme turning of the winds at low-levels, and consequently lead to brief spinups. In contrast, the head-on (parallel) collision of two boundaries would likely result in a broader and more linear-shaped storm cluster, intensifying then weakening once the temporary source of enhanced convergence was lost (nonetheless helpful for lifting and pushing more parcels to the level of free convection). A warning forecaster should not however hesitate to issue a Tornado Warning if their confidence is high enough. This will likely not be the case for several years until higher resolution radar data becomes available, but may be possible near higher resolution TDWRs.

A Call-To-Action statement was developed for Special Weather Statements to include the potential for landspouts and funnel clouds. This statement highlights a landspout being a short duration tornado with winds of generally less than 60 mph, or weak EF0 strength. However, it highlights that minor damage and injuries can still result for anything or anyone in its direct path. The statement informs the public that a Tornado Warning may be issued if atmospheric conditions continue becoming more favorable for landspout formation. The WFO Melbourne Warning Coordination Meteorologist and Severe Weather Program Leader have incorporated the author's suggested statement into WarnGen. The 2011 wet season will be the first where this Call-To-Action statement is available for forecasters to use in a Special Weather Statement for landspouts.

WFO MLB has several templates for Special Weather Statements (and Significant Weather Advisories) highlighting hazards such as wind, hail, lightning and funnel clouds. One of the statements alerts for the threat of funnel clouds and landspouts with the above Call-To-Action statement now as an option. Therefore, if forecasters see a similar scenario to the one in this case, they will have a prepared statement to inform the public of landspouts.

Figures

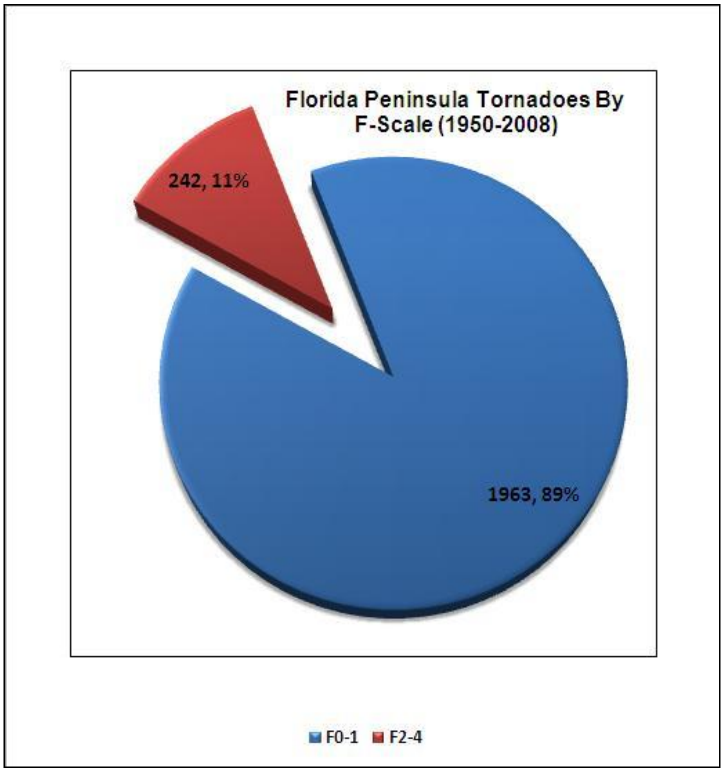

FIG. 1. Division of weak (F0-1) and moderate to strong (F2-4) tornadoes across Florida from 1950 to 2008.

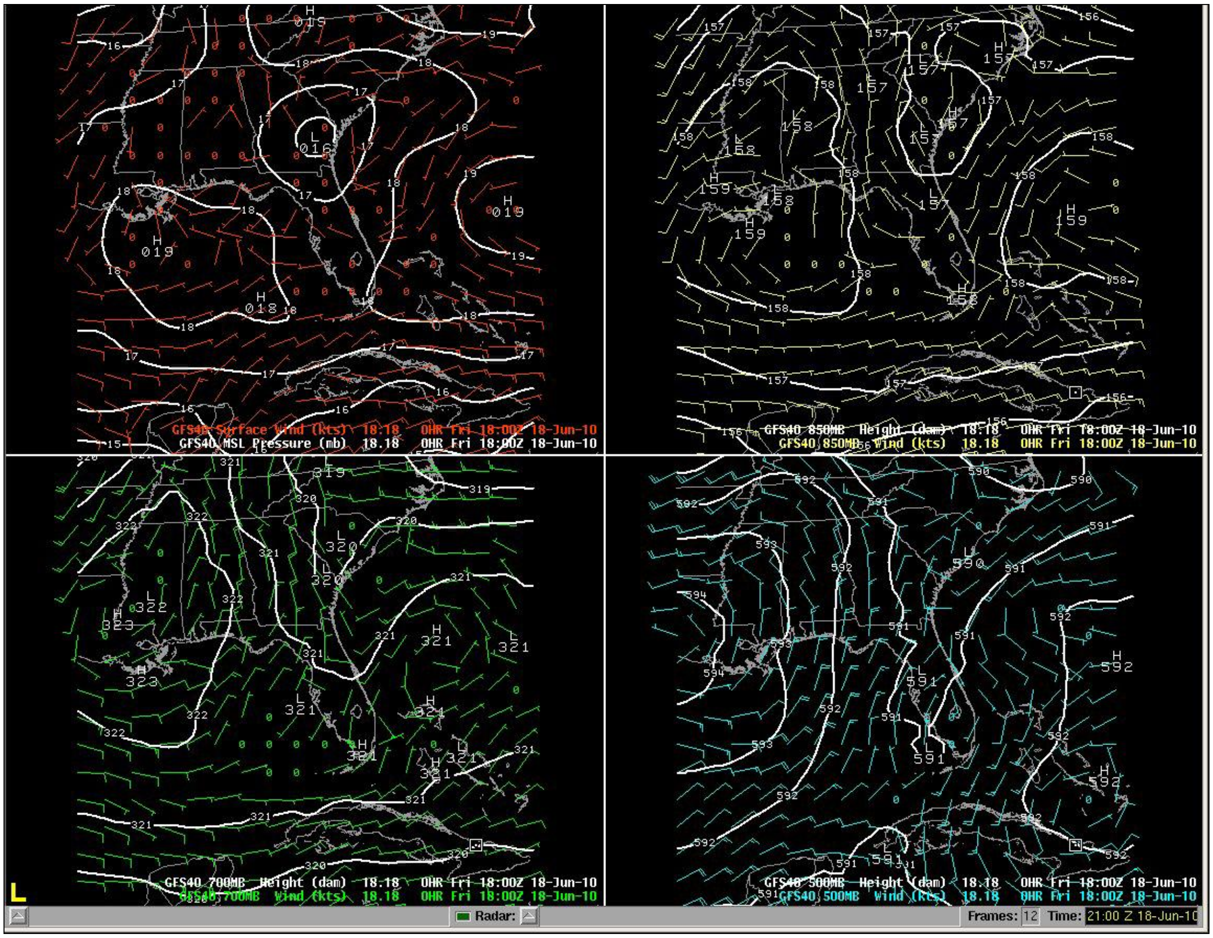

FIG. 2. 1800 UTC GFS initialization showing MSLP and surface wind (upper-left), 850 mb heights and wind (upper-right), 700 mb heights and wind (lower-left) and 500 mb heights and wind (lower-right).

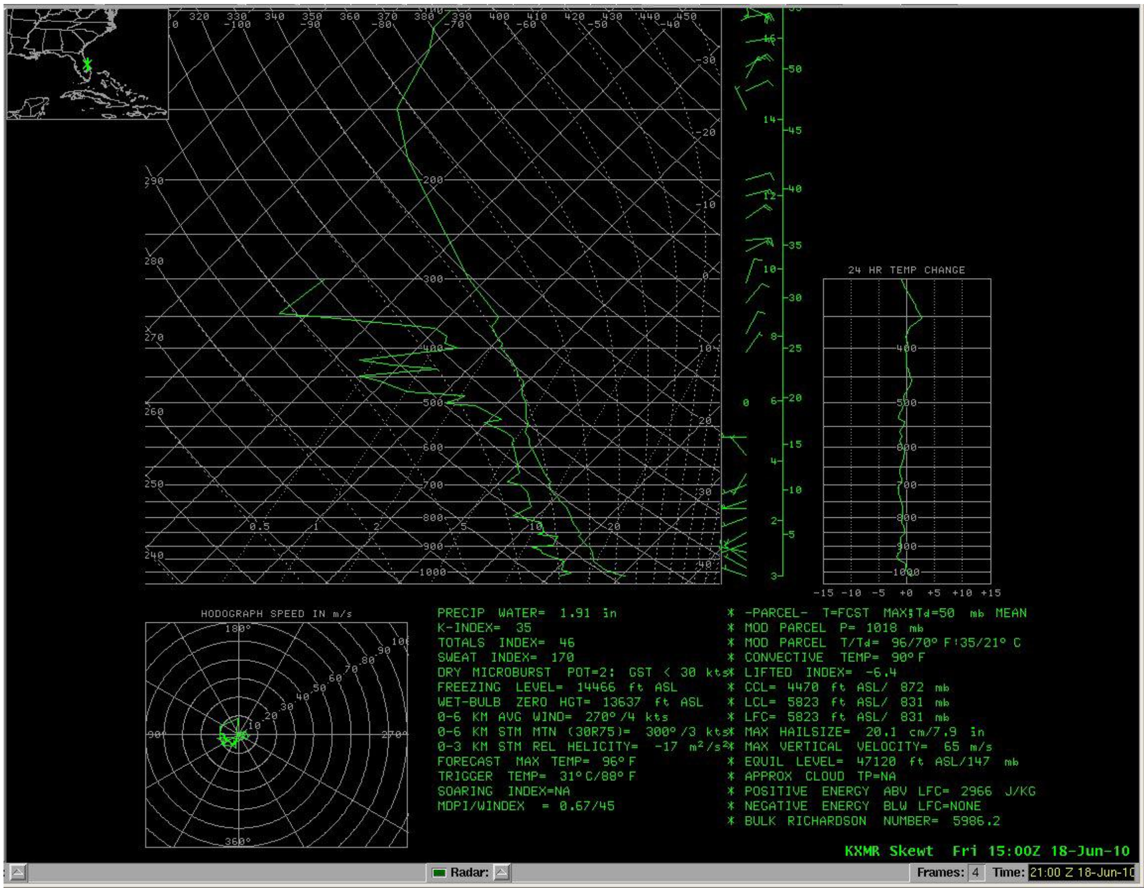

FIG. 3. 1500 UTC Cape Canaveral, Florida (XMR) sounding.

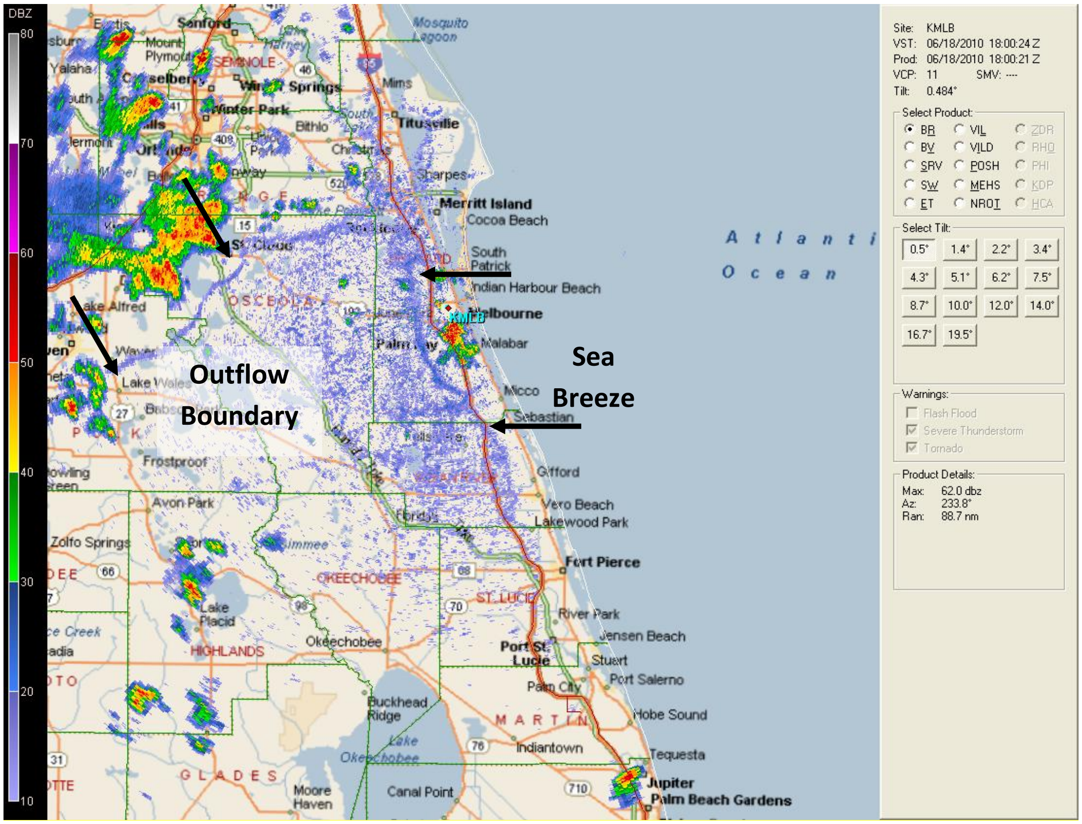

FIG. 4. 1800 UTC KMLB Base Reflectivity depicting convection southeast of Orlando with an associated outflow boundary moving ahead of it.

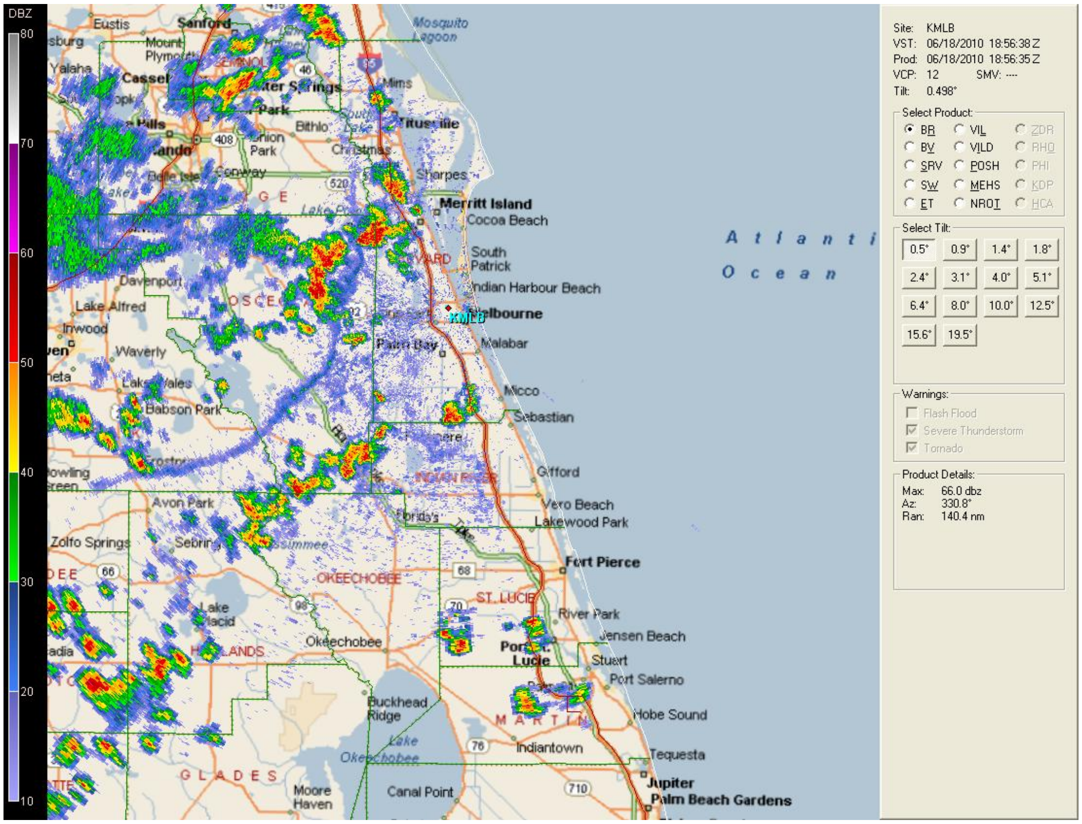

FIG. 5. 1856 UTC KMLB Base Reflectivity illustrating a line of storms developing as a result of the outflow boundary and sea breeze colliding, as well as cellular development near Port St. Lucie.

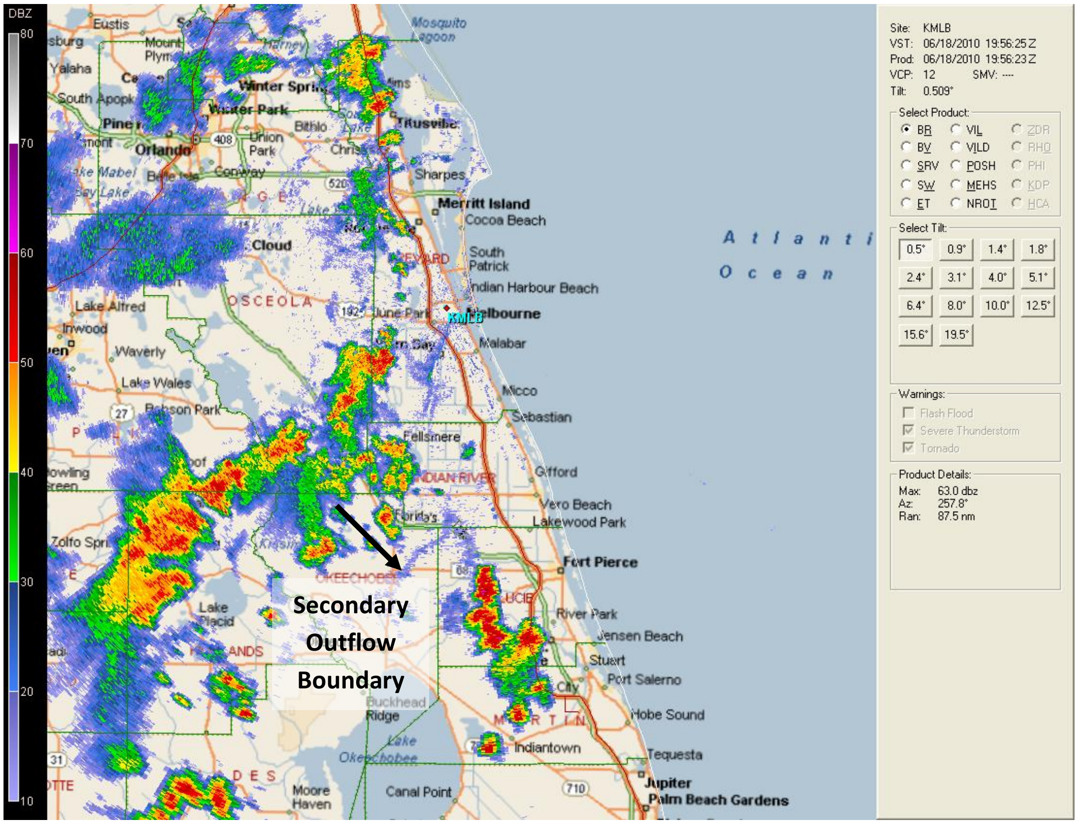

FIG. 6. 1956 UTC KMLB Base Reflectivity showing a secondary outflow boundary produced from the line of storms caused by the initial outflow boundary.

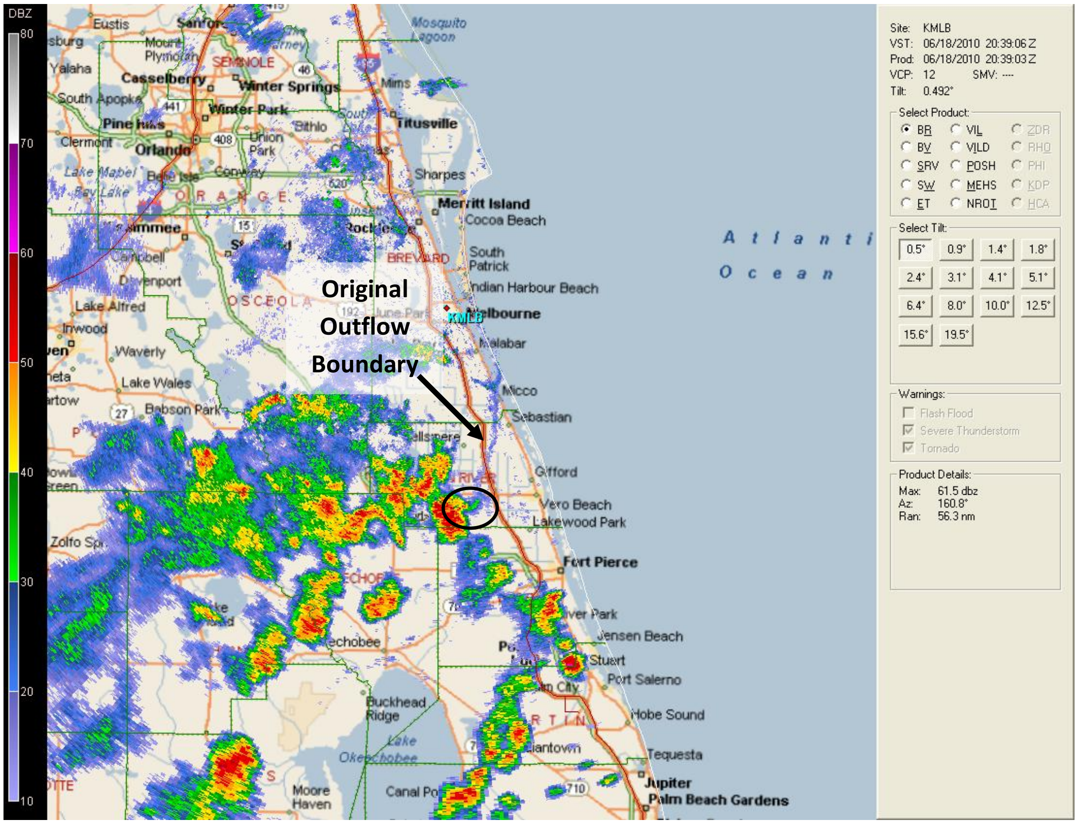

FIG. 7. 2039 UTC KMLB Base Reflectivity of additional thunderstorm initiation as original southeastward moving outflow boundary intersects northward moving convection (circled area).

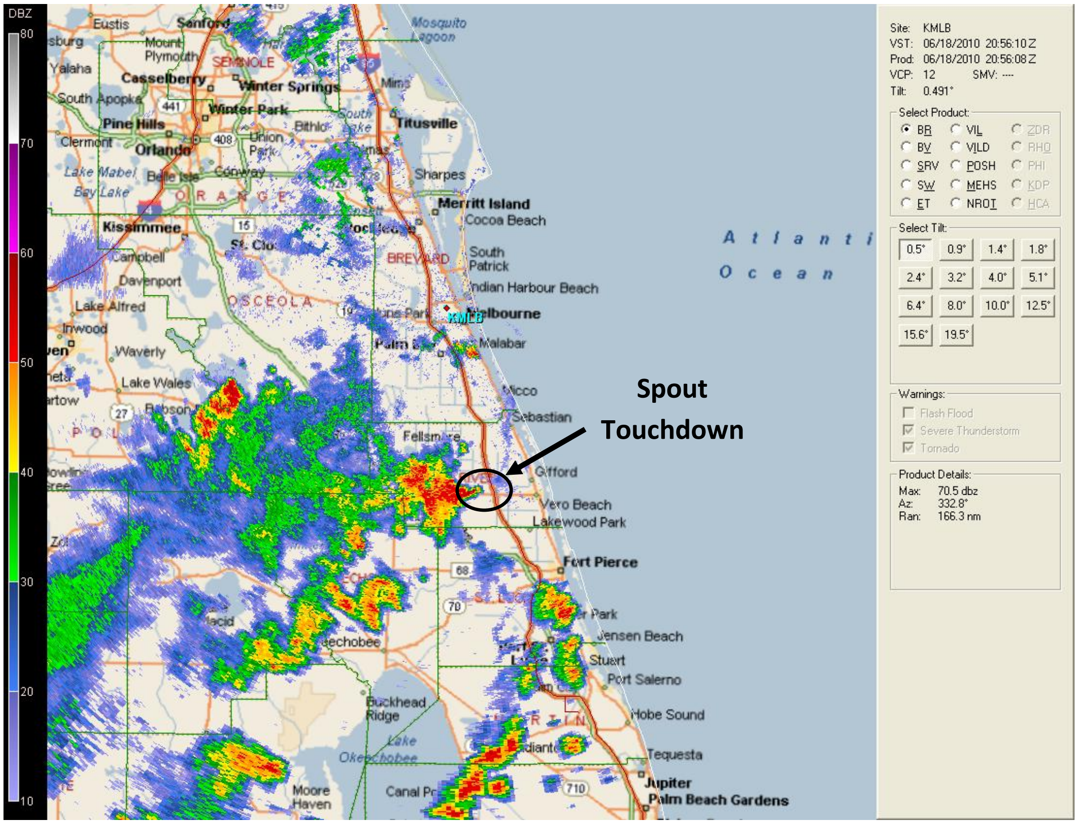

FIG. 8. 2056 UTC KMLB Base Reflectivity at the time of landspout touchdown.

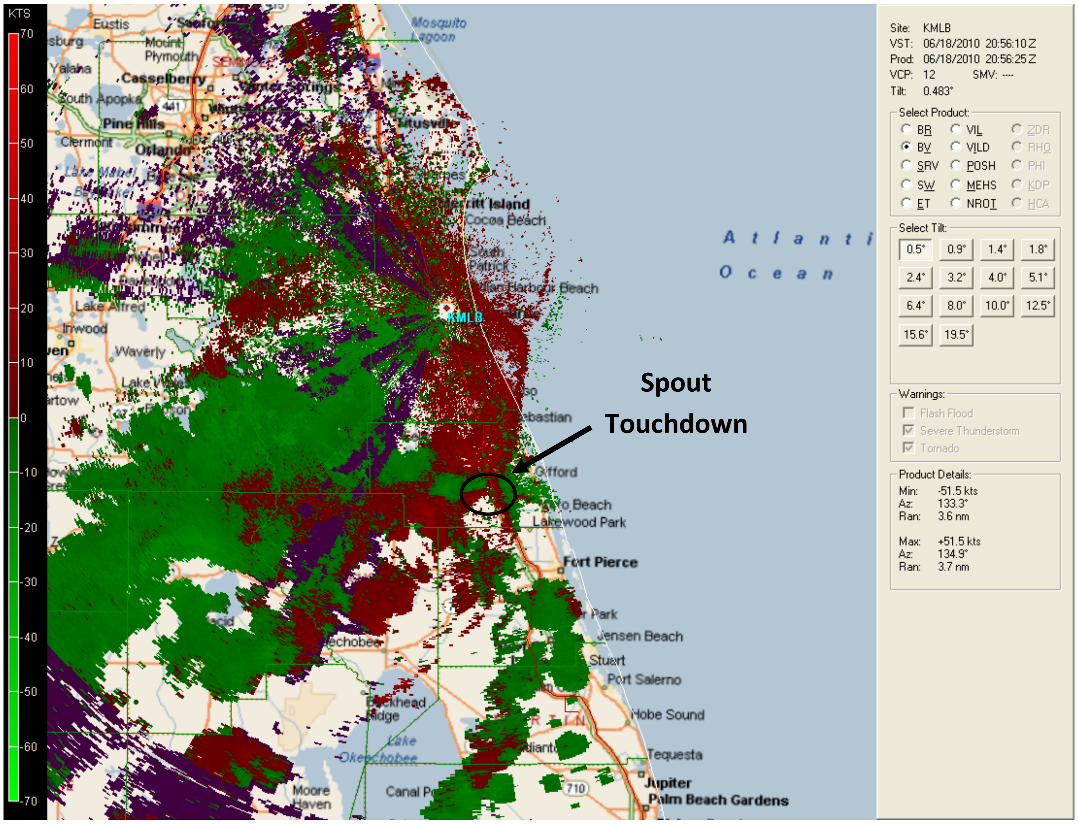

FIG. 9. 2056 UTC KMLB Base Velocity at the time of the landspout.

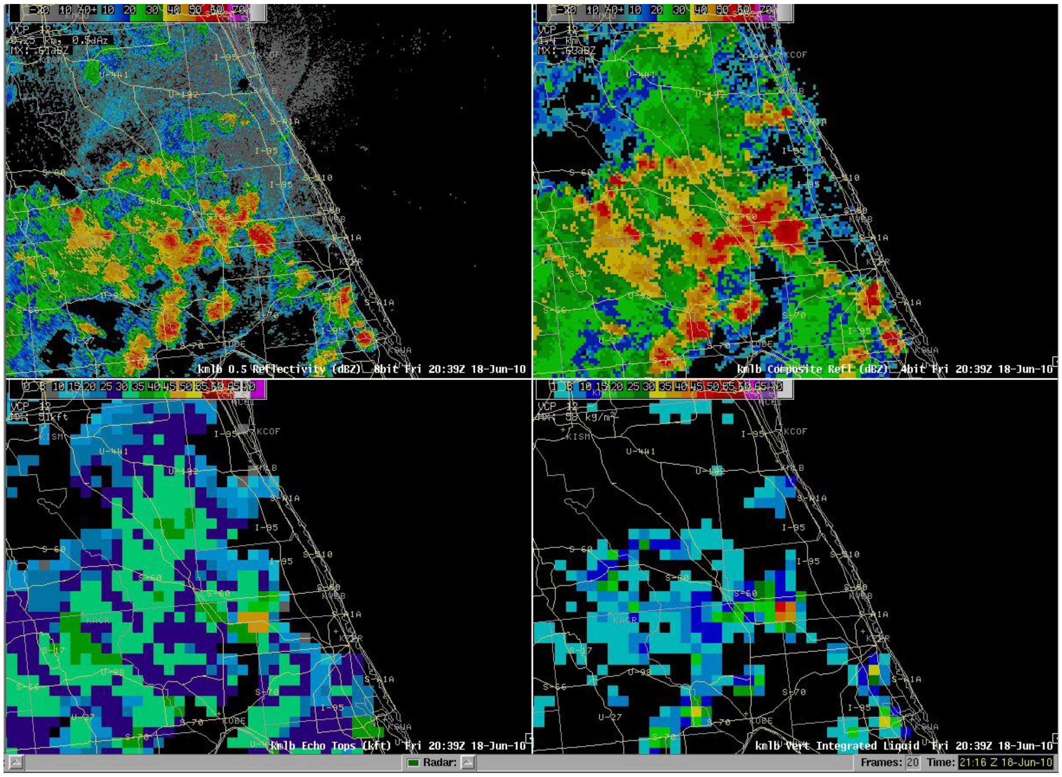

FIG. 10. 2039 UTC KMLB Base Reflectivity (upper-left), Composite Reflectivity (upper-right), Echo Tops (lower-left) and VIL (lower-right).

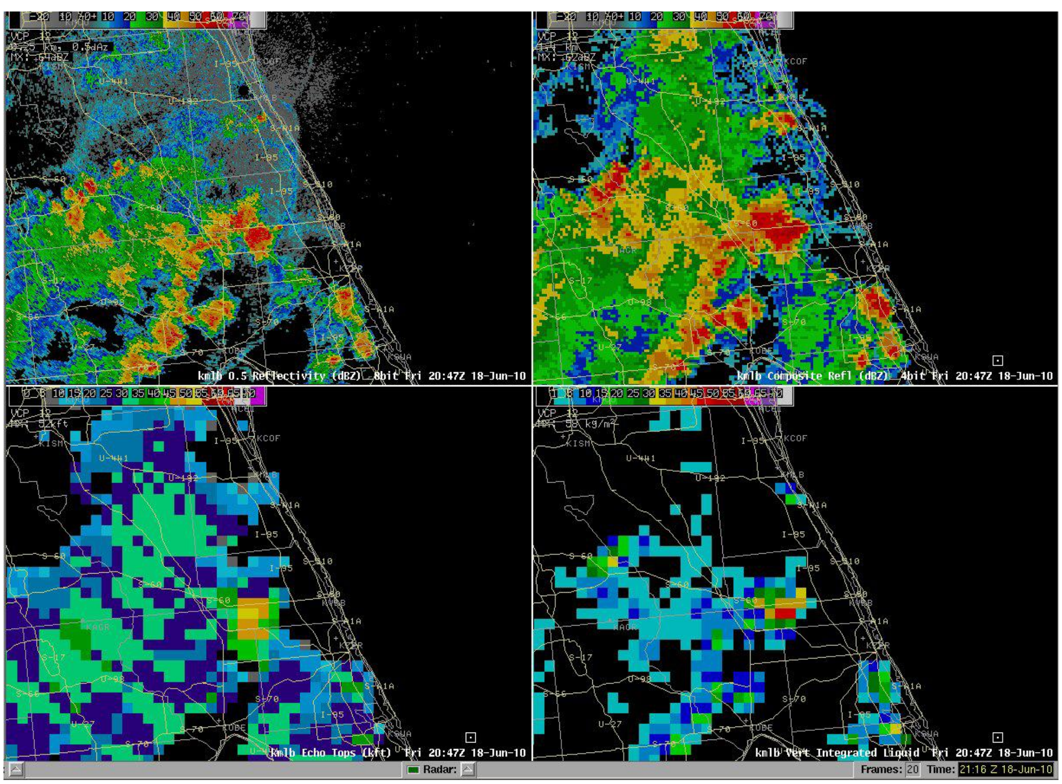

FIG. 11. Same as FIG. 10 except at 2047 UTC.

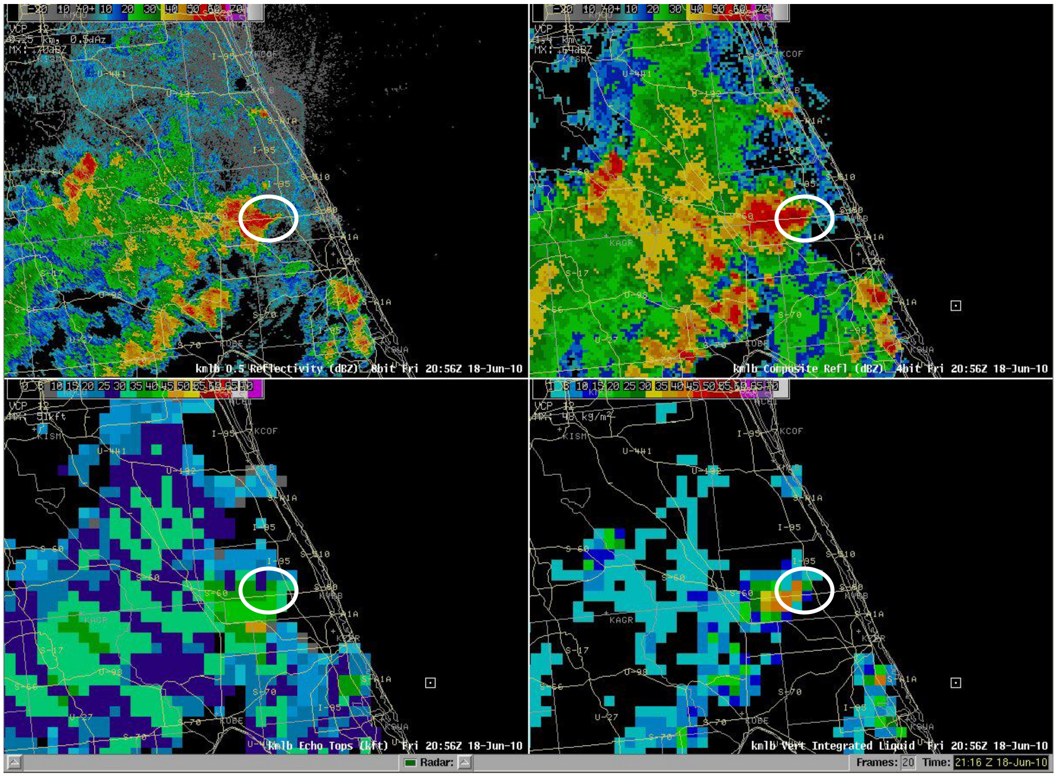

FIG. 12. Same as FIG. 10 except at 2056 UTC during the time of the landspout touchdown. White circle denotes landspout touchdown.

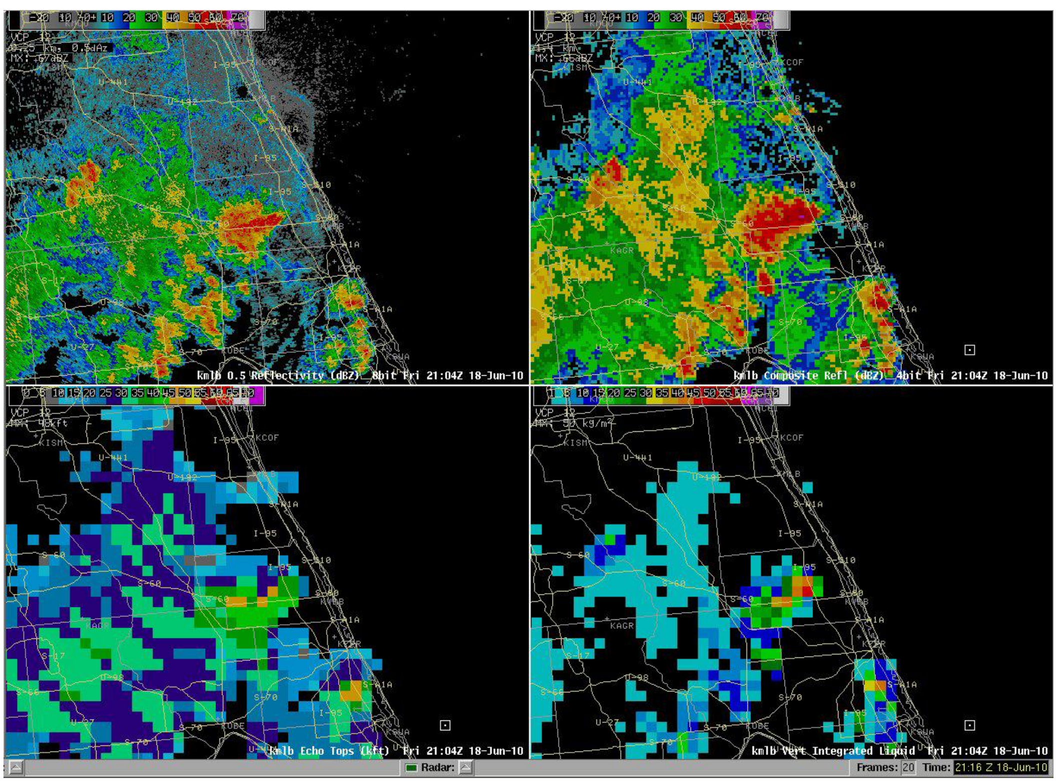

FIG. 13. Same as FIG. 10 except at 2104 UTC.

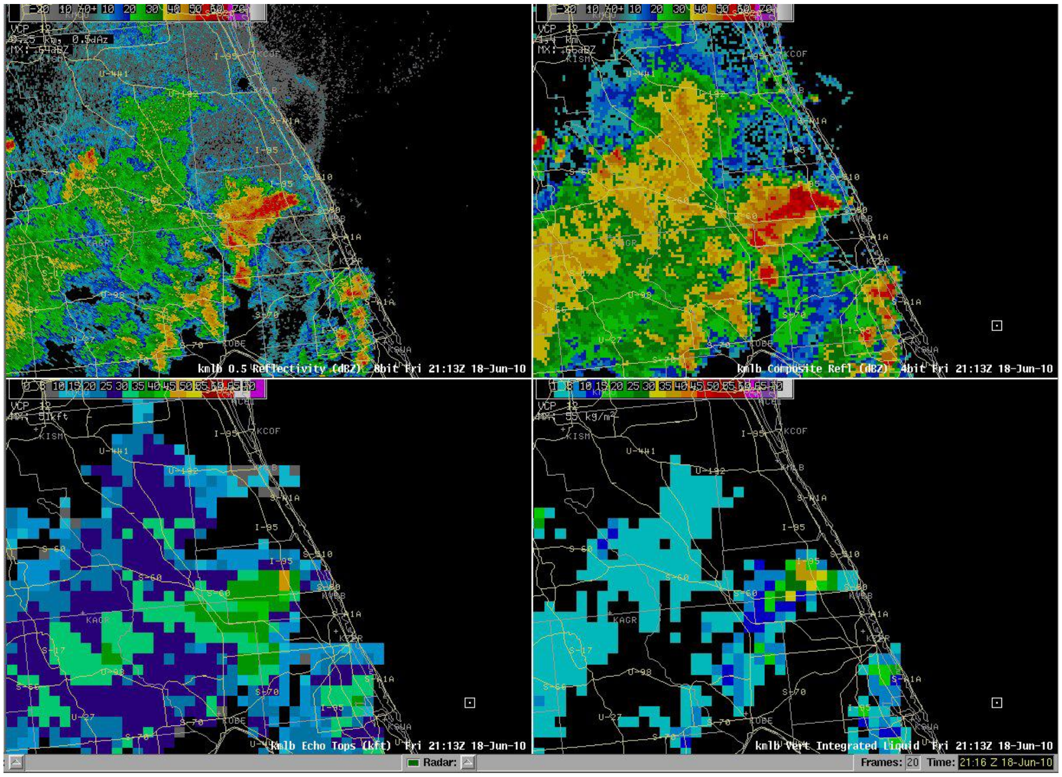

FIG. 14. Same as FIG. 10 except at 2113 UTC.

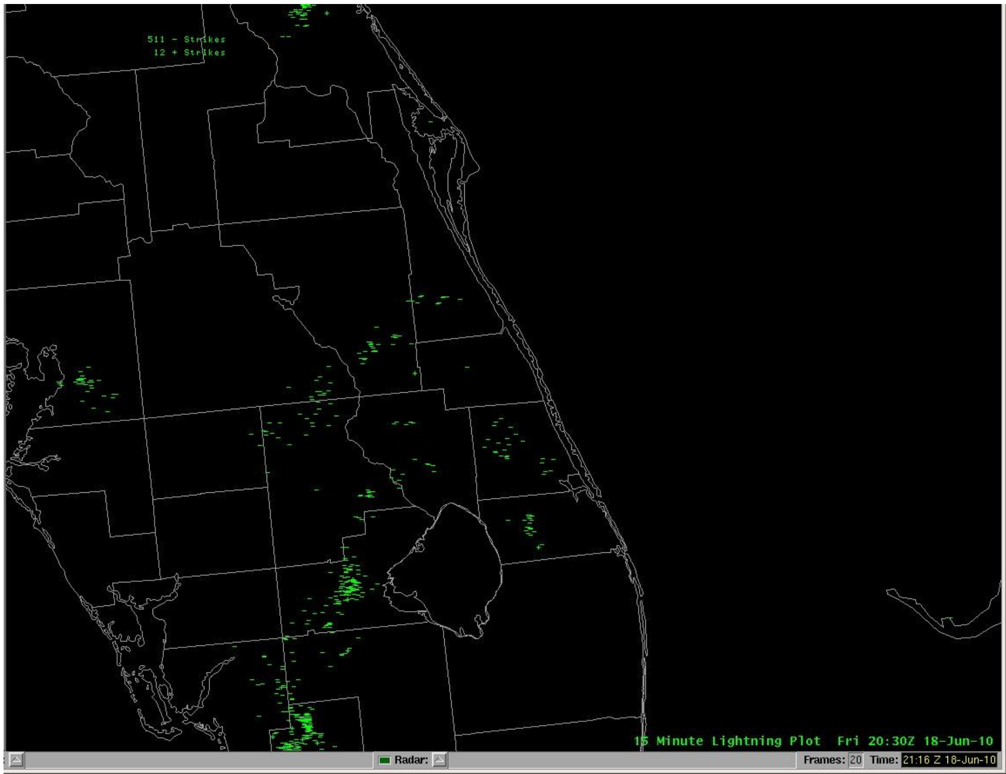

FIG. 15. 2030 UTC 15 Minute Lightning Plot.

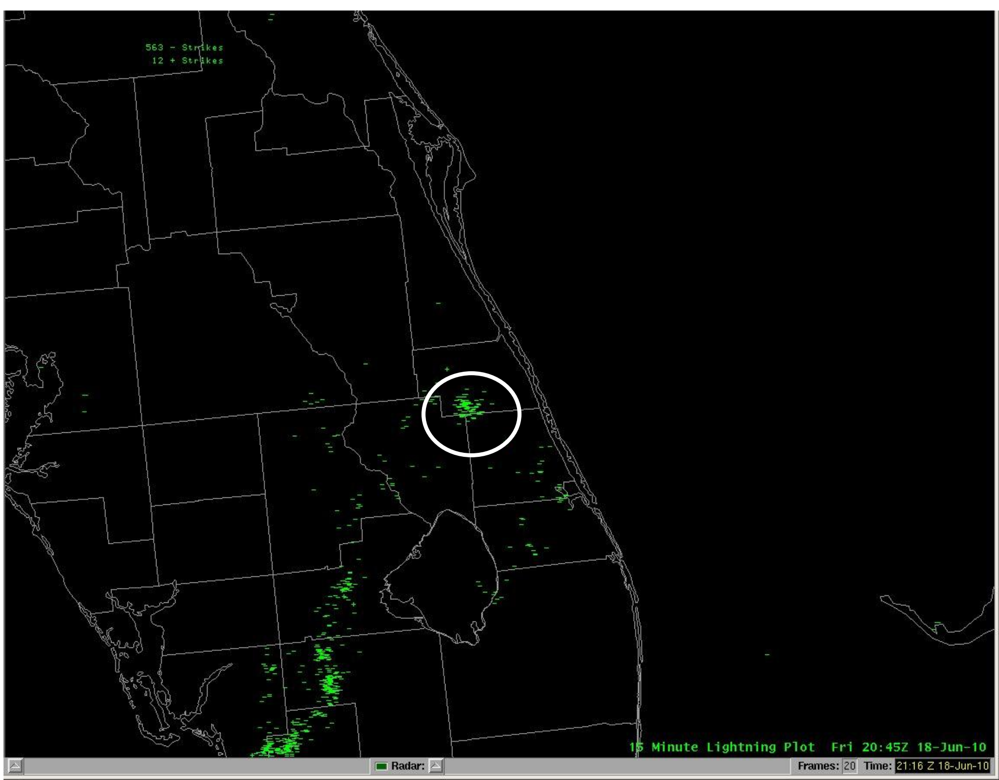

FIG. 16. Same as FIG. 15 except at 2045 UTC. White circle indicates landspout producing storm.

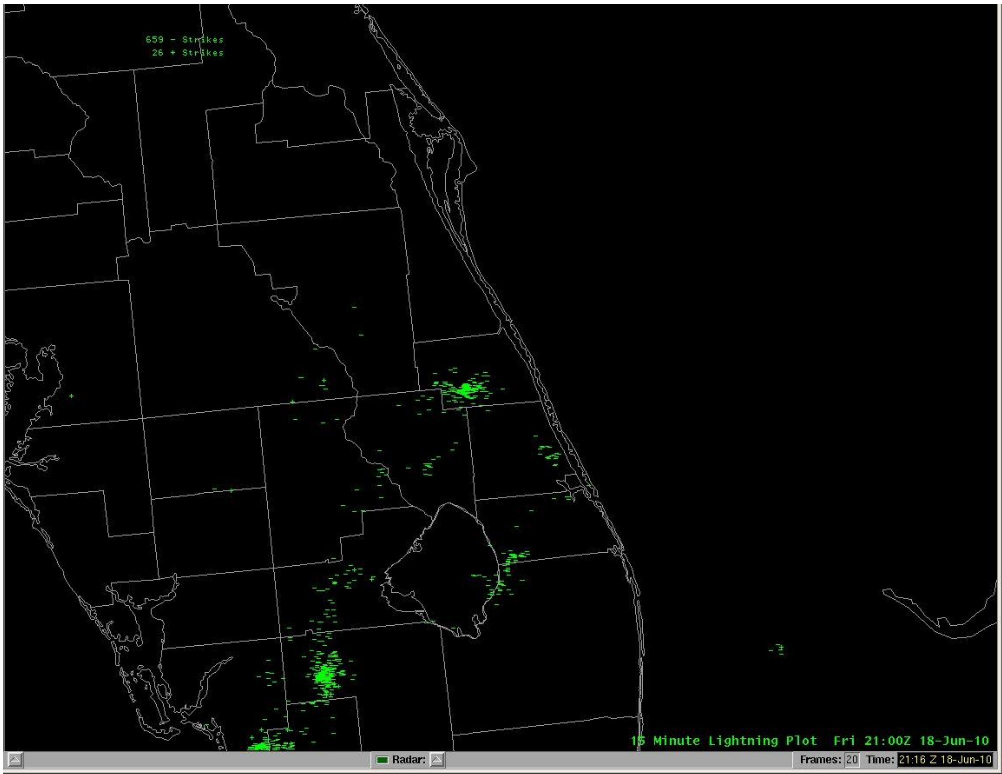

FIG. 17. Same as FIG. 15 except at 2100 UTC.

FIG. 18. Same as FIG. 15 except at 2115 UTC.

Acknowledgements

The author would like to thank the staff at WFO MLB for all of their help and suggestions with this case study.

Reference

Choy, B.K., and S.M. Spratt, 1993: **A WSR-88D Approach to Waterspout Forecasting.** NOAA Tech. Memo. NWS SR-156, 29pp.